

RESEARCH ON TEMPERATURE: LIMITING FACTOR OF DEVELOPMENT OF TOMATO LEAF MINER *TUTA ABSOLUTA* (MEYRIK)

(LEPIDOPTERA: GELECHIIDAE)

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ABSTRACT

The objective of this work is to study the effect of temperature variations on the biology of the tomato leaf miner *Tuta absoluta*. The duration of the development cycle of this bioaggressor was 18.5 ± 2.52 days at 30 ± 1 ° C, 32.9 ± 4.22 days at 21 ° C. ± 1 ° C and 71.5 ± 12.16 days at 15 ± 1 ° C. Similarly fertility depends on the temperature. The number of eggs laid per female varies between 28 and 260 eggs. The analysis of variance applied to the effect of temperature on the stages of development of *T. absoluta* and egg incubation shows a very highly significant difference obtained with a probability of less than 0.01. The potential number of generations calculated in the Algiers region in 2009 was 8.3. In 2010 it is equal to 7.72.

KEYWORDS: *Tuta absoluta*, Tomato, Effect of Temperature, Algeria

INTRODUCTION

The tomato leaf miner *T. absoluta* has become in a short time the most devastating pest of tomato in Algeria since its introduction in summer 2008 (GUENAOUI, 2008). This bioaggressor develops during all life stages of the culture (RAVENA, 1991, DE SOUZA and REIS, 1986) where the damage can reach 100% of the crop due especially to the larvae usually attack the leaves but also stems, flowers and even fruits (SOUZA *et al* 1992.). Diversification, intensification and global trade have helped to change, sometimes disrupt crop pest situations, especially when new pests are introduced, such as the tomato pinworm. In effect *T. absoluta* is a neotropical microlepidoptera of the Gelechiidae family, which feeds on the solanaceae. This pest is widely answered South America (MOORE, 1983 HAJI *et al*, 1995). It is reported for the first time in Argentina in 1964 after importing tomatoes from Chile. In March 2007, serious damage is observed on tomato in Valencia, Spain (VIEIRA, 2008). In Italy, the presence of *T. absoluta* is mentioned in spring 2008 in the province of Cosenza in tomato grown in greenhouses. Then the species has spread to the south of France in September of the same year (EOPP, 2009). It is reported in other countries in Eastern Europe. Gradually this borer invades other countries where infestations are found in North Africa, the Middle East and other Asian countries. According to CHAPMAN (1998) the temperature is one of the most important abiotic factors affecting the biology of insects, it causes alterations in the body. The objective of this research is to study the effect of temperature on the different stages of development as well as on female fecundity of this pest.

METHODOLOGY

At the beginning we started with a more precise determination of the species in the study of male and female genitalia. The method starts with killing insects with ethyl acetate. The abdomen of each insect killed is placed in a solution of potash at 10% on an electric hot plate for 10 minutes. After washing with distilled water the genitalia are

separated from the rest of the stomach and placed in different alcohol baths (70°, 100°). Genital part is spread in a drop of Faure liquid. The preparation is then placed in a sterilizer at 50 ° C for 48 hours for drying.

The experience was conducted at the Entomology Laboratory of the National Institute of Plant Protection (NIPP) El Harrach Breeding is carried out in three bedrooms (Humidity: 70%, photoperiod 12 H). Three temperatures are chosen for the study (15° C, 21° C, 30° C). Tomato leaves infested with tomato leaf miner are put in cages in each of the three bedrooms. Butterflies are then recovered and couples. The retrieved eggs are left to incubate. Just after their hatching, neonate larvae are placed on tomato plants planted in plastic pots 5 Kg, larval development is recorded until pupal stage which determines the overall duration of the development cycle *T. absoluta* under the influence of each of the three temperatures.

For the study of fertility, adults obtained are grouped in pairs and put in tubes in the presence of droplets of honey. They are left in place until their death. Only couples who gave eggs are considered.

Comparison of zero development of *T. absoluta* by the different temperatures studied can highlight the existence of any errors during the experiment to try to reduce the impact of these. Zero development is calculated by the following formula

$$Z_0 = \frac{Nt_1 \times t_2 - Nt_2 \times t_1}{Nt_1 - Nt_2}$$

Z0 = is zero development, Nt 1 is the duration of one cycle in temperature S 2 is the duration of the cycle in the temperature, t1 temperature, t2 temperature 2

RESULTS

Male Genitalia

The reproductive *T. absoluta* consists of several parts (Figure 1a). The two symmetrical valves are slightly curved, they are composed of two portions each separated by a constriction in the middle. The upper part is hairy. It has a notch in the inner part called costa. In the middle between the two valves gnathos which has the shape of a horseshoe is observed. The transtilla consists of two small rooms sclérotinisées and melanized. The penis is the only organ detachable genitalia. In *T. absoluta* aedeagus penis or of cylindrical form, has a rounded base extended by a long process terminated by a notch at its end. Ejaculatory duct is found inside the arm and opening located near the notch.

Female Genitalia

The copulatory apparatus of the female occupies a large part of the abdomen (Figure 1b). In the segment IX and X anal lobes are found, rounded and very hairy which is parallel accolent the two tubes of the mastoid later. Two other tubes are found in segment VII and the anterior process is placed against the antrum. The copulatory bursa oblong occupies half of the genital part. Signum is a very important part in the systematics of Lepidoptera. For *T. absoluta*, it consists of two small adjacent stems of different sizes, and dark in color.

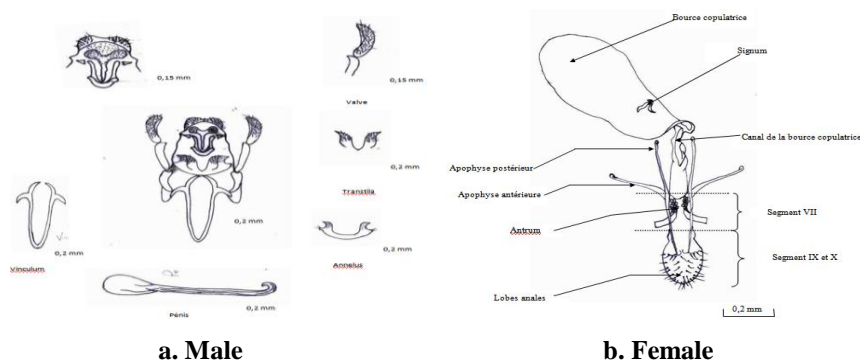


Figure 1: Genitalia of *T. absoluta* (Original)

Effect of Temperature on the Development of *T. absoluta*

The development of *T. absoluta* shows a difference in the duration of the different states of the cycle according to the three temperatures (Table 1). The experience helped save an average incubation period equal to 12.1 ± 2.4 days at 15°C . At 21°C it is equal to 6.2 ± 0.7 days and 4.1 ± 1.1 days at 30°C . According to the three temperatures, larval development requires 23 ± 3.1 days at 15°C , 13.3 ± 1.2 days at 21°C and 7.9 ± 1.2 days at 30°C . The pupal state lasts 36.4 ± 9.5 days at 15°C , 13.4 ± 2.2 days at 21°C and 6.5 ± 0.9 days at 30°C . Thus, at a temperature of $30^\circ \text{C} \pm 1^\circ \text{C}$ the shortest cycle with 18.5 ± 2.52 days was recorded. Insects at a temperature higher than $15^\circ \text{C} \pm 1^\circ \text{C}$ showed the longest cycle with 71.5 ± 12.16 days, whereas at $21^\circ \text{C} \pm 1^\circ \text{C}$ this time was 32.9 ± 4.22 days.

Table 1: Duration of the Cycle of *T. absoluta* According to the Temperatures (15°C , 21°C and 30°C)

	Duration (Days)		
	15°C	21°C	30°C
Incubation	$12,1 \pm 2,4$	$6,2 \pm 0,7$	$4,1 \pm 1,1$
Larval stage stage	$23 \pm 3,1$	$13,3 \pm 1,2$	$7,9 \pm 1,2$
Pupation	$36,4 \pm 9,5$	$13,4 \pm 2,2$	$6,5 \pm 0,9$
Cycle	$71,5 \pm 12,16$	$32,9 \pm 4,22$	$18,5 \pm 2,52$

Variation in Fecundity of *T. absoluta* According Temperatures

The evaluation of the average fecundity of females of *T. absoluta* according temperatures is recorded in Figure 2. The number of eggs laid per female varies from one couple to another and from one temperature to another. At 15°C the minimum egg output per female is 64 eggs and maximum to 190 eggs, which corresponds to an average of 122.9 ± 44.2 eggs. At 21°C , the values fluctuate between a minimum of 28 eggs and a maximum of 115 eggs giving an average of 67 ± 26.4 eggs per female. The values recorded at 30°C reached a maximum of 260 eggs and a minimum of 30 eggs which was used to calculate an average fertility equal to 71.4 ± 70.9 eggs per female.

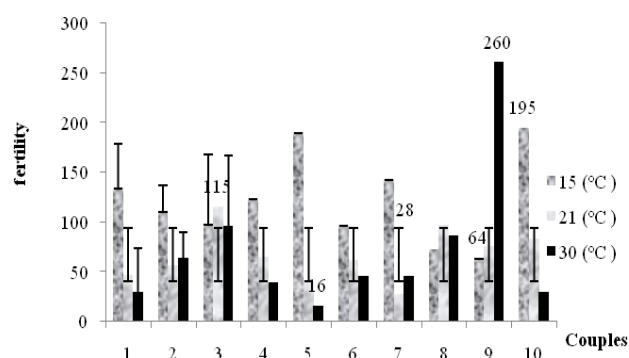


Figure 2: Fecundity of Females of *T. absoluta* According to Temperatures

Effects of temperature on the Longevity of Adult *T. absoluta*

Adult longevity of *T. absoluta* is an important consideration in studies of the biological cycle parameter because it is related to the number of clutches forming the new generations of the pest. In this study longevity is studied at three different temperatures, 15 °C., 21° C. and 30°C.

Depending on the temperature adults of *T. absoluta* have very different life periods. At 15 ° C. it varies between 8 and 22 days for males (18.73 ± 4.17) and between 23 and 31 days for females giving an average of 26.73 ± 2.46 days. Longevity at 21 ° C. between 5 days and 9 days (7 ± 1.41) for males and between 9 and 16 days in females with an average of 12.13 ± 1.77 days. At 30 ° C the adult males of *T. absoluta* live between 1 and 4 days (2.6 ± 0.99) and females between 5 and 9 days. Females whose body is rich in yolk substances show a greater longevity than males 6.47 ± 1.73 .

Analysis of Variance of the Effect of Temperature on the Development of *T. absoluta*

The purpose of the ANOVA is to highlight the existence of any significant differences between the temperatures and durations of developmental stages of *T. absoluta*. The results on the use of analysis of variance for the search of any significant difference between the effects of temperature on the incubation, larval development, pupal state and fertility of pest are carried successively in Tables 2, 3, 4 and 5.

The analysis of variance shows a very highly significant difference obtained with a probability of less than 0.01, between the effects of three temperatures. Duration of egg incubation, larval and pupal development changes the tomato leaf miner (*T. absoluta*). Likewise, this analysis reveals the presence of a significant difference between the effects of three temperatures on fertility of *T. absoluta*. Recorded the probability is less than 0.05.

Study Zero Development of *T. absoluta*

The calculation of zero development gave the results shown in Table 2

The zero growth recorded is between 8.7 ° C and 9.3 ° C for the incubation of eggs and between 6.0 ° C and 6.3 ° C for larval development. Regarding the pupal state zero development has three values 11.5 ° C., 11.7 ° C. and 12.5 ° C. Zero global development is equal to 9.8 ° C confirming that the tomato leaf miner is an insect that can simply lower temperatures to complete its cycle. Given this result we can expect a large number of generations per year.

Table 2: Zero Development of Tomato Leaf Miner

Zero Development /Stage	Incubation	Larval Stage	Pupation
	8,9	6,2	11,7
Zero dvp. global	9,8		

Dvp. : Developement

Estimated Number of Potential Generations in the Algiers Region

The use of average monthly temperatures in the region of Dar El Beida years 2009 and 2010 brought in Table 1 gave a sum of useful degrees (ΣS) equal to 3055.7 ° C. Constant (s) calculated from the zero development 9, 8 ° C. is equal to 368.5 ° C. which in a given number of potential generations of *T. absoluta* equal to 8.3 generations per year, a 9th generation partial Note. In 2010, the sum of useful temperatures (ΣS) recorded from January to September is equal to 2474 ° C. Compared to the constant (s), the number of potential generations of TPW in the same region is equal to 7.72.

In the theoretical case in different regions mentioned the tomato cultivation is done in the field, the largest number of generations concern Biskra with 13 generations, 1 partial. Presumably both the Algerian coastline than at the Tell Atlas medium altitude not exceeding 600 m, the estimated number of generations would be 9 generations with one partial.

DISCUSSIONS

Our result confirms that of BADAoui *et al.* (2008) who report that *T. absoluta* valves are slightly bent with a notch in their inner portions, and a large expansion in the central parts in the form of teeth. The gnathos is shaped like a horseshoe. PHILPOTT (1927) reports that in *Phthorimaea operculella*, a species of the same family as the tomato leaf miner has a swelling at the basal part. Similarly BADAoui and BERKANI (2010) reported that the vinculum in the tomato leaf miner is longer than wide. PHILPOTT (1927) reports that the aedeagus is longer than is usual in other species of Gelechiidae. In the male of *Myelois decolor*, the penis is subcylindrical a little thicker at the base and deeply indented (DOUMANDJI 1981) summit.

The mastoid in the locust borer is present in the form of two tubes club at their ends (DOUMANDJI 1981). According to FAT (1955), the form of signum differs in two species of Gelechiidae. Indeed for *Strobisia iridipennella* is shaped oval two neighboring scholarships while in *Farulta triangulella* it looks like the letter W. The signum *Ephesia kuehniella* is composed of a large tube attached to three small dark spots (DOUMANDJI, 1981).

The cycle of development of *T. absoluta* depends on climatic conditions. Indeed, the development of this bioaggressor shows a difference in the duration of the different states of the cycle based on three temperatures. The average duration of embryogenesis is equal to 12.1 ± 2.4 days at 15°C . At 21°C ., it was 6.2 ± 0.7 days and 4.1 ± 1.1 days at 30°C . These data confirm those of HAJI *et al.* (1988) and COELHO and FRANCA (1987) who reported an incubation period of 4.3 days at 27.0°C , 4.8 days at 22.8°C . and 5.1 days at 18.6°C . Larval development requires 23 ± 3.1 days at 15°C ., 13.3 ± 1.2 days at 21°C and 7.9 ± 1.2 days at 30°C . These values are close to those of ESTAY (2000) reported a larval duration of 12.2 days at 27°C ., 19.8 days at 20°C . and 38.1 days at 14°C . According to this study pupation lasts 36.4 ± 9.5 days at 15°C ., 13.4 ± 2.2 days at 21°C . and 6.5 ± 0.9 days at 30°C . According HAJI *et al.* (1988) and COELHO and FRANCA (1987), the pupal state requires 6.2 days at 27°C . 10 to 11 days near 22.8°C . and 9.7 days at 18°C . Thus we obtain a temperature of $30 \pm 1^{\circ}\text{C}$. the shortest cycle, with 18.5 ± 2.52 days. Insects at a temperature higher than $15^{\circ}\text{C} \pm 1^{\circ}\text{C}$ showed the longest cycle with 71.5 ± 12.16 days, whereas at $21^{\circ}\text{C} \pm 1^{\circ}\text{C}$. this duration was 32.9 ± 4.22 days. These results are similar to those of ESTAY (2000) studied the cycle of the pest three different temperatures (14°C ., 20°C . and 27°C .). For this author at 14°C . the overall development time of *T. absoluta* from egg to adult is 76.4 days at 14°C . and 67.3 days at 20°C . It is equal to 23.8 days at 27°C . According PEREYRA *et al.* (2006), at 25°C . the overall cycle time of the miner is equal to 27.98 ± 0.23 days.

The number of eggs per female at 15°C . corresponds to an average of 122.9 ± 44.2 eggs. At 21°C . We recorded an average of 67 ± 26.4 eggs per female. At 25°C ., LEBDI *et al.* (2010) gives higher values of fertility with an average ranging between 110.4 ± 8.1 and 229.3 ± 15.4 eggs per female eggs. Values recorded at 30°C . in this study reached a minimum of 30 eggs and a maximum of 260 eggs. This result is similar to that recorded by IMENES *et al.* (1990) with a fertility rate which varies between 145 and 262 eggs. UCHÔA-FERNANDES *et al.* (1995) reported a maximum of 260 eggs per female. In an artificial culture medium and MIHSFELDT PARRA (1999) have 183 eggs per female.

Depending on temperatures, adults of *T. absoluta* have very different life periods. Our results approach those of HAJI *et al.* (1988) and COELHO and FRANCA (1987) who argue that adult *T. absoluta* live 7.5 to 36.47 days and females much longer than males. Similarly ESTAY (2000) notes a different lifetime between males and females, it varies between 6 and 7 days for males and 10 and 15 days for females

Zero Development *T. absoluta* is recorded between 8.7°C . and 9.3°C . for egg incubation and between 6.0°C . and 6.3°C . for larval development. Regarding the pupal state zero development has three values 11.5°C ., 11.7°C . and

12.5 °C. Zero global development is equal to 9.8 °C. These values are already reported by MAHDI *et al.* (2010) and justify those advanced by DESNEUX *et al.* (2010) who state that the development of zero is equal to 6.9 ± 0.5 °C. for eggs, 7.6 ± 0.1 °C. for larval and 9.2 ± 1.0 °C for the pupal development which gives a zero overall development equal to 8.1 ± 0.2 °C. ESTAY (2000) estimates a zero equal development at 7 °C. for embryogenesis, 7,6 °C. for larval development and 9.1 °C for pupation. The larvae of the tomato leaf miner can stay alive for several weeks at 4°C (VERCHER *et al.*, 2010).

CONCLUSIONS

The effect of three temperatures 15 ° C., 21 ° C. and 30 ° C. shows differences in the duration of the different states of the development cycle of the tomato pinworm. A 30 ± 1 ° C. cycle appears shorter with 18.5 ± 2.52 days. Insects amounted to 15 ° C. ± 1 ° C. have a long cycle with 71.5 ± 12.16 days. At 15 ° C. longevity of male moths is 18.73 ± 4.17 , the female show an average lifespan of 26.73 ± 2.46 days. Similarly, the average life expectancy at 21 ° C. between 7 ± 1.41 days for males and 12.13 ± 1.77 days for females. At 30 ° C the adult males of *T. absoluta* live an average of 2.6 ± 0.99 days, for against females live longer with a mean of 6.47 ± 1.73 days. The number of eggs laid per female varies with temperature. The highest value was recorded at 30 ° C with 260 eggs. For the cycle, zero development of *T. absoluta* is 9.8 ° C. The number of potential generations of this pest calculated in the Algiers region in 2009 is equal to 8.3 generations per year, a 9th generation partial Note. In 2010, the number of potential generations of tomato leaf miner the same region is equal to 7.72.

ACKNOWLEDGEMENTS

At the end of this work, I warmly thank Professor Salaheddin DOUMANDJI of higher agronomic El Harrach National School who led the study. My gratitude also goes to Ms. Amel ABABSIA from the NIPP for his help and advice.

REFERENCES

1. Badaoui M. I. & Berkani A. (2010) Morphologie et comparaison des appareils génitaux de deux espèces invasives *Tuta absoluta* Meyrick et *Phthorimaea operculella* Zeller. VII^{ème} Conférence Internati. franc. entomol., Louvain la Neuve, 5 – 10 Juillet 2010, p. 83.
2. Badaoui M.I., Berkani A. & Benouared F. (2008). Identification et comparaison des génitalia de deux Gelechiidae : *Tuta absoluta* Meyrick et *Phthorimaea operculella* Zeller. 7^{èmes} Journées sci. techn. phytosanit., Lab. prot. vég. Univ. Mostaganem : 1 - 9.
3. Chapman R.F. (1998). The insects: Structure and function, Cambridge, Cambridge University Press, 770p. Coelho M.C.F. & Franca F.H., (1987). Biologia, Quetotaxia da larva e descrição da pupa e adulto da traça do tomateiro. *Pesquisa agro. Pecuária Brasileira*, 22 (2) : 129 – 135
4. De Souza, J.C. & Reis, P.R. (1986). Controle da tracea -do-tomateiro em Minas G erais. *Pesquisa Agropecua Ária Brasileira* 21, 343 - 354.)
5. Desneux N., Wajnberg E., Wyckhuys K. A. G., Burgio G., Arpaia S. Narvaez-Vasquez C. A., Lez-Cabrera J.G., Ruescas D. C., Tabone E. Frandon J., Pizzol J., Poncet C., Cabello T. & Urbaneja A., (2010). Biological invasion of European tomato crops by *Tuta absoluta* : ecology, geographic expansion and prospects for biological control. *J. Pest. Sci.*, 83 : 197 – 215.
6. Doumandji S.(1981) Quelques phycites en Algérie. *Bull. Zool. agri.*, (1) : 8 - 19. Estay P., 2000 – Polilla del

- tomate *Tuta absoluta* (Meyrick) Informativo, la platina. *Inst. investigacion agro pécunia, centro régio.investig. la Platina*, : 1 – 4.
7. Grasse P. P. (1955) *Traité de Zoologie. Anatomie, systématique, biologie. Insectes supérieurs et hémiptéroïdes*. Ed. Masson et Cie, Paris, T. X, Fasc. I, pp. 1 - 975.
 8. Guenaoui Y. (2008) Nouveau ravageur de la tomate en Algérie. Première observation de *Tuta absoluta*, mineuse de la tomate invasive, dans la région de Mostaganem, au printemps
 9. Haji F.N.D., Oliviera C.A.V., Amorim-NETO M. S. & Batista J.G.S. (1988) Fluctuação populacional da traça do tomateiro no submédio. *Pesquisa Agro. Pecuária. Brasileira*, 23 (1) : 7 – 14
 10. Haji, F. N. P.; Freire, L. C. L.; Roa, F. G.; Silva, C. N. Sousa Júnior, M. M. & Silva, M. I. V. (1995). Manejo integrado de *Scrobipalpuloides absoluta* (Povolny) (Lepidoptera: Gelechiidae) no Submédio São Francisco. *An. Soc. Entomol. Brasil*, Jaboticabal 24, 587.
 11. Imenes S. D. L., Fernandes M. A. U., Campos T. B. & Takematsu A. P (1990) Aspectos biológicos e compartamentais de traça do tomateiro *Scrobipalpula absoluta* (Meyrick, 1917) (Lepidoptera, Gelechiidae). *Arquivos Instituto biologico*, 57 (1 – 2) : 63 – 68.
 12. Lebdi Grissa K., Skander M., Mhafdhi R. & Belhadj R. (2010). Lutte intégrée contre la mineuse de la tomate *Tuta absoluta* Meyrick (Lepidoptera, Gelechiidae). 7^{ème} Conférence internationale francophone d'entomologie, Louvain la Neuve, 5 – 10 juillet 2010, p. 92.
 13. Mahdi K., Daoudi-Hacini S., Saharaoui S., Ababsia A., Aouamer F., Imaghazen F. & Doumandji S. (2010). Détermination du zéro de développement de la mineuse de la tomate *Tuta absoluta* (Meyrick). *Journées Nati. Zool. agri. for.*, 19 - 21 avril 2010, *Dép. Zool. agro. for., Inst. nati. agro., El Harrach*, p. 103.
 14. Mihsfeldtl H. & Parra J.P.R., (1999). Biologia de *Tuta absoluta* (Meyrick, 1917) em dieta artificial. *Scientia Agricola* 56 (4) :
 15. MOORE, J. E. (1983) Control of tomato leaf miner. *Tropical Pest Management*, London, v. 29, n. 3, p. 231-238, 1983.
 16. O.E.P.P. (2009). Organisation Européenne de Protection des Plantes —Ravageurs et maladies. No 8, Paris, 1 – 8.
 17. PEREYRA P.C. and SANCHEZ N. (2006) Effect of two Solanaceous plants on developmental and population parameters of the tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *Neotropical Entomology*, 35 (5) : 671 - 676
 18. Philpott A. (1927). The Male genitalia of the New Zealand Gelechiidae. *Nelson Philo. Soc.*, : 348 – 356.
 19. Ravena, S. (1991). Manejo integrado de p raga s d o tomateiro, in *A nais do 2o Encontro Nacional de Produçã oes A baste cimento de Tomate, Jaboticabal, Brazil*, 8-11 October, 1991, p p. 105 - 157.
 20. Souza, J. C. De Reis, P. R. & Salgado L. O. (1992). *Traça-dotomateiro:histórico, reconhecimento, biologia,prejuízos e controle*. Boletim Técnico No 38, EPAMIG, Belo Horizonte, Brazil
 21. Uchoa-Fernandes MA, Della Lucia T.M.C. & Vilela E.F., (1995). Mating, oviposition and pupation of *Scrobipalpula absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *An. Soc. Entomol. Brasil*, 24 : 159 – 164.

22. Vercher R., Calabuig A. & Felipe C. (2010). Ecología, muestreos y umbrales de *Tuta absoluta* (Meyrick). *Phytoma Espana*, 217 : 23 – 26.
23. Vieira M.M. (2008). Mineira do tomateiro *Tuta absoluta* un nova ameaza a production de tomate V^{ème} Semin. internati. tomat. industrial, Mora, 23 fevereiro 2008.